Lesson Six

Introduction to multifactorial traits

Overview
Students explore human diversity by examining some of their own traits and discuss whether each trait is determined by genes, the environment, or a combination of both genes and environment. Students graph their class data for mid-digital finger hair and height onto two histograms and discuss the distribution of these two traits in their classroom population. They discuss what factors contribute to the development of type 2 diabetes and develop an expanded understanding of what is considered an environmental factor for diseases like diabetes.

Enduring understanding:
Most traits are determined by a combination of genetic and environmental factors, including complex diseases like type 2 diabetes.

Essential question:
What is a multifactorial trait and how might this apply to type 2 diabetes?

Learning objectives
Students will be able to:

- Interpret histograms they make showing the distributions of two different traits
- Identify traits that are determined by genes only, by the environment only, or by a combination of genes and environment
- Write a definition for multifactorial trait and provide an example

Prerequisite Knowledge
Students should have an understanding of the following terms: trait, gene, genetic factor, environmental factor

Time: 50 minutes

This lesson connects to the Next Generation Science Standards in the following ways:
Performance Expectations
HS LS3-3 Apply concepts of probability to explain the variation and distribution of expressed traits in a population.

HS LS3.B Disciplinary Core Idea
Variation of Traits: Through sexual reproduction, new genetic combinations result in genetic variation. Environmental factors also affect expression of traits. Thus variation and distribution of traits observed depend on both genetic and environmental factors.

This lesson highlights the Scientific Practices of **Analyzing and Interpreting Data** and the Crosscutting Concept of **Cause and Effect**

Materials

Materials	Quantity
Two histograms drawn on white board or poster paper to record student data on mid-digital finger hair and height (Figure 6.1)	1 per class
Venn diagram drawn on white board or poster paper (Figure 6.2)	1 per class
2"x 3" sticky notes	2 per student
Student Resource: *Genetic traits images*	1 per group
Student Sheet 6: *Exploring diversity in the classroom* (2-sided)	1 per student

Lesson Preparation

- Make two histograms like the ones shown in Figure 6.1 by drawing them on a board or making them on poster paper. Make sure that the spacing along the x and y axes is the right size for the corresponding size and number of sticky notes.
- Draw a Venn diagram on the board or poster paper as shown in Figure 6.2

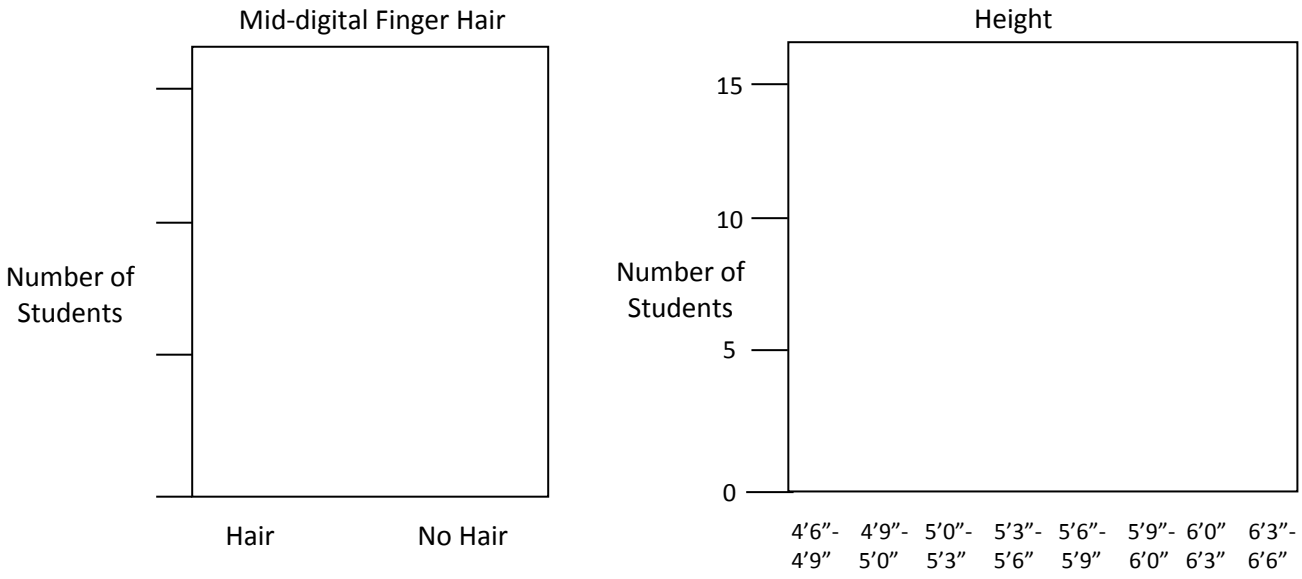


Figure 6.1. Histograms showing distributions of two traits among students in classroom

Procedures

Part 1 (Engage): Trait Assessment (*15 minutes*)

1. Tell students that in today's lesson they will be assessing some of their physical characteristics, or ***traits***. The lesson focuses on traits that can be seen, such as height and hair color. Remind students, however, that many traits cannot be seen by looking at a person, such as how well their body breaks down lactose or gluten, or how adept their red blood cells are at transporting oxygen.

2. Hand out the Student Resource: *Genetic Traits Images* to groups of students and review the traits. Show students the two class histograms, and demonstrate how each student will record their data for mid-digital finger hair and height on the two histograms by placing a sticky note along the x-axis at the position for their trait. When/if there is more than one sticky note at a single position, students should place sticky notes one above the other in a straight column.

3. Hand out Student Sheet 6: *Exploring diversity in the classroom* and two sticky notes to each student. Ask students to complete Parts A and B of the sheet (the front page) using the images in the Student Resource to help them score the traits. They may want to work in pairs, but each student should fill out a sheet based on their own traits. Students should not fill in the right column at this time. Ask them to record their data on the two class histograms, and then record the class data on their handouts.

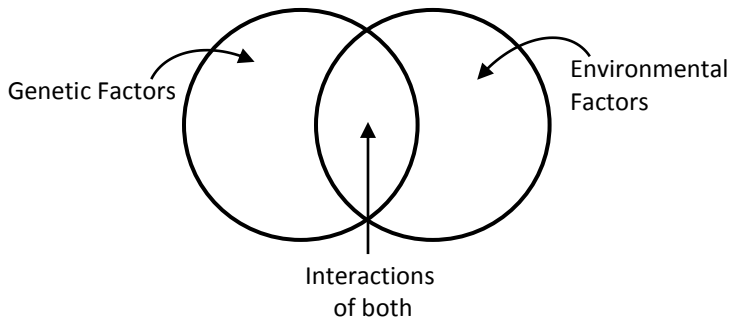
> ***Note:*** Be sensitive to any students who may not wish to share their information with the class for whatever reason. Encourage them to participate as they feel comfortable.

Part 2 (Explore and Explain): Exploring Diversity in the Classroom (*15 minutes*)

4. Gather the class back together, and ask students what they notice about the distribution of traits on the two histograms. Students should notice that finger hair come in two versions, while there is a wide range of heights distributed roughly in a bell curve. Depending on your class population, the distribution of heights may be bimodal, with a peak of shorter heights corresponding to females and higher heights for males. This is not always the case.

5. Ask students what determines whether or not a person has mid-digital finger hair. Finger hair is determined by a gene. Depending on the versions of the gene (people have 2 copies of each gene), the person may or may not have hair on the middle joint of their fingers. While most traits result from the interaction of many genes, mid-digital finger hair is relatively easy to identify as a single genetic trait since it is a Yes/No trait.

6. Using the Venn diagram (see Figure 6.2) write "mid-digital hair" in the circle labeled "Genetic Factors.



Note: Some teachers recommend not labeling the Venn diagram at the beginning of the lesson. Start the discussion with examples of traits that can be clearly categorized, such as mid-digital hair (genetic), hair length (environmental), and height (both). Elicit the labels for the Venn diagram from the students, then move on to characteristics that are more difficult to categorize.

Figure 6.2 Venn diagram showing factors that determine traits

7. Next, ask students to suggest what factors determine a person's height. Students will probably recognize that height is determined by genes, because people who are tall usually have tall parents. However, they should also recognize that environmental factors like nutrition, childhood diseases, and general health also contribute to a person's height.

8. Height is an example of a ***multifactorial*** trait. Use this example to develop a definition of multifactorial traits. Here is one possible definition: Multifactorial traits are traits that are determined by the interaction of genetic and environmental factors. The genetic contribution usually involves multiple genes. Many environmental factors can also contribute.

9. Using the Venn diagram, write "height" at the intersection of the two circles, showing that the trait is the result of a combination of interactions between genes and the environment.

10. Ask students to reconsider each of the traits they assessed using Student Sheet 6: *Exploring diversity in the classroom.* Using the right-hand column of Part A, have students mark each trait on a scale of 1 to 5, with 1 being *all genetic factors*, 5 being *all environmental factors*, and 3 being an even interaction of both genetic and environmental factors.

G ⟷ E
1 2 3 4 5

11. As a class, discuss the placement of each trait on the Venn diagram and write each one on the appropriate part of the diagram as students come to consensus. Make sure students understand that there are few right and wrong answers—there is much current research about the relative contributions of both genes and environment to human traits, including health and behavior, and still much to be discovered. As such, how a student supports his or her claim about the placement of a trait may be more important than the actual placement.

Part 3 (Elaborate): Diabetes as a multifactorial trait (*15 minutes*)

12. Ask students to think about where type 2 diabetes would be placed on the Venn diagram. Before placing t2d in the middle intersection, challenge each person to think of at least one genetic factor and one environmental factor that contributes to t2d. For environmental factors, you may need to encourage students to consider things that are not part of their physical environment but that none-the-less are considered as environmental, such as access to healthy food options, or having access to areas to exercise safely. Examples of each may include:

Some genetic factors influencing t2d:

- Inheritance: T2d runs in families, which suggests a genetic link
- Identical twins have a high correlation of t2d
- Variation by ethnicity: Certain ethnicities are have higher incidences of t2d, which points to genetics
- Gene variants: Variations in certain specific genes that increase susceptibility to t2d have been identified
- Weight gain: A person's tendency to become overweight or obese has a genetic component, and this increases a person's risk for t2d.

Some environmental factors influencing type 2 diabetes:

- Nutrition: This varies from excellent to poor depending on the quality and amount of food a person eats
- Health care: Access to health care; whether there are barriers preventing people from receiving appropriate care and prevention
- Exercise: Whether or not a person gets routine exercise
- Food access: A person's access to healthy food options within their communities
- Public spaces: Access or lack of access to sidewalks, parks, bike lanes
- Air quality: This includes poor air quality due to pollution for cars, dust storms, chemical sprays, etc., as well as good air quality that is free from these contaminants
- Toxins: Environmental toxins, naturally occurring and those occurring from manufacturing
- Sanitation: Access to sewage and garbage disposal systems within the community, clean water supply, clean toilets
- Stress levels: Higher levels of stress contribute to type 2 diabetes
- Sleep: Getting fewer than 5 hours of sleep per night has been significantly associated with type 2 diabetes

> ***Note:*** Factors that can lead to the development of a disease condition are called **risk factors**, and factors that help prevent the disease are called **protective factors**. Lesson Six will explore this more deeply.

Closure (Evaluate) (*10 minutes*)

13. Ask students:

"We saw in Lesson One how quickly this disease is spreading across the nation. How does one go about understanding a complex, multifactorial condition like type 2 diabetes in order to treat it, prevent it or research the disease?"

Make sure that students understand that multifactorial diseases like type 2 diabetes are very complex to both treat and investigate. Scientists must look for both genetic and environmental factors that may contribute to disease susceptibility.

"How does this relate to our Driving Question: ***How can the growth of type 2 diabetes in the Yakima Valley be slowed?"***

"Which is easier to influence and change—genetic factors or environmental factors?"

While the symptoms of some genetic conditions or diseases may be treated with medications, making changes to the genes themselves is not yet an option for t2d—in fact, scientists are still working on identifying which genes are involved.

Changing environmental factors may seem easier on the surface, but often involve changing large economic, social, and political structures which influence health, as well as those involving issues of poverty and race. Personal behavioral changes may be some of the most controllable environmental factors.

14. As closure and evaluation, students can finish questions 1 – 5 on the Student Sheet 6 either in class or as homework, depending on remaining class time and teacher preference.

Extensions:

- A description of the connection between diabetes and environmental pollution can be found in a May, 2013 BBC article titled: *Diabetes: dirty air 'may raise' insulin resistance risk.* http://www.bbc.co.uk/news/health-22465389
- Challenge students to bring in current new articles that detail possible genetic contribution(s) to a certain behavior or condition.
- Optional discussion: When discussing environmental factors and how they may influence traits, consider introducing the following discussion in class: Is age an environmental factor or a genetic factor, in the development of traits? Age as a risk factor is introduced more completely in Lesson Six in reference to being a risk factor mentioned by a risk test published by the ADA, so this would be a great time to get students thinking about it. Have students consider age as a risk factor, in regards to their general understanding about aging, but also thinking about how different stages in life are accompanied by different life styles, such as puberty which is accompanied typically by an increase in calorie consumption, or the early 20's

which is often accompanied by a decrease in physical activity (going from high school sports to not being as active/"freshman 15")

Glossary

Trait: A characteristic or attribute of an individual.

Multifactorial traits: Traits that are determined by the interaction of genetic and environmental factors.

POSSIBLE ANSWERS

For Student Sheet 6: *Exploring diversity in the classroom*

1. What do you notice about the distribution of your class traits for mid-digital finger hair and height? What does this tell you about the kinds of traits these are?

   Finger hair has two possible forms, having it and not having it, while height has a wide range of options. This is because mid-digital finger hair is a single gene trait, while height is determined by more than one gene (and environment as well).

2. Name two multifactorial traits, and explain how both genetic and environmental factors contribute to each trait.

Multifactorial Trait 1: *athletic ability*	
Genetic Factor	Environmental Factor
Many genes, such as those that code for fast-acting muscles, good coordination, strength	*Physical training, healthy diet, adequate sleep*
Multifactorial Trait 2: *skin color*	
Genetic Factor	Environmental Factor
Genes for skin pigments (melanins)	*Amount of UV exposure, wind exposure, state of health*

3. Which category do you think most human traits fall into, genetic, environmental, or multifactorial? *Most human traits are multifactorial.*

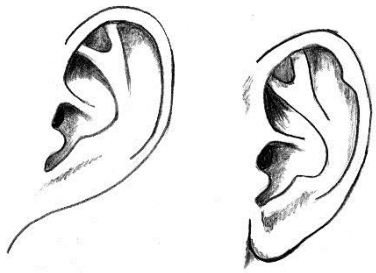
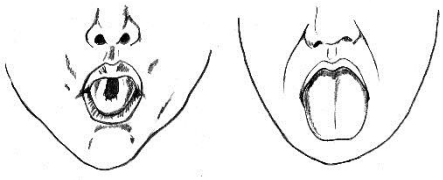
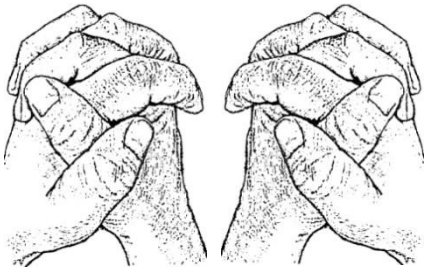
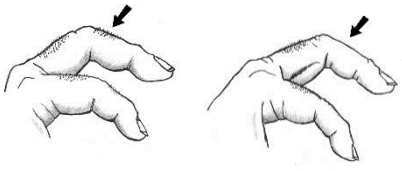
4. What category does type 2 diabetes fall into? Justify your answer.

   Type 2 diabetes is multifactorial because many genetic and environmental factors contribute to whether someone will develop it.

5. What are the implications of your answer to the previous question on the study of diseases like type 2 diabetes?

   Multifactorial diseases like type 2 diabetes are very complex to investigate. Scientists must look for genetic and environmental factors that may contribute to disease susceptibility. On the plus side, conditions with an environmental component can sometimes be prevented or treated through modification of environmental factors.

Genetic Traits Images

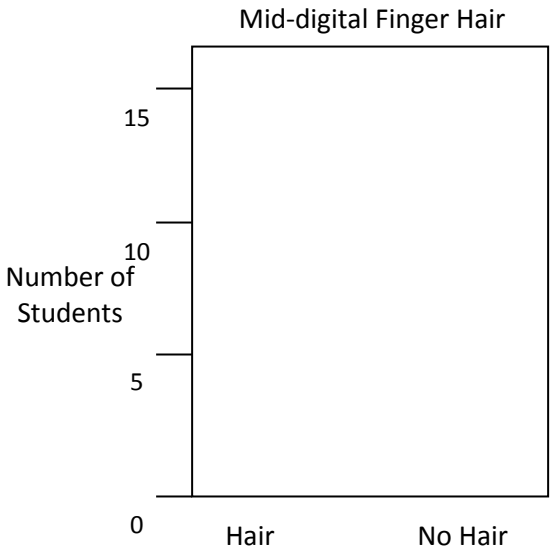
Earlobes	**Tongue Rolling**
	
Attached Free	Rolls tongue Can't roll tongue
Earlobes are attached if the bottom lobe is attached directly to the head. Earlobes are free if the lobe hangs free.	Tongue rolling is the ability to roll your tongue upwards to form a closed tube. The sides of your tongue will meet at the top of the tube if you can roll your tongue. Tongue rolling is an example of a "motor skill" that is inherited.
Thumbs	**Mid-digital Finger Hair**
	
Left over Right over	Hair No hair
When you interlock your fingers, which thumb goes on top? Try interlocking your fingers without thinking about how you are doing it, and look at which thumb is on top, left or right. Although you can probably force yourself to do it with the opposite finger on top, one way usually feels more natural.	Your fingers have 3 segments, top, middle, and bottom. If hair is present on the middle segment of any finger, even just one hair or one finger, you have mid-digital hair. Do not score the bottom finger segment for hair, just the middle segment. Look closely, as it can be difficult to score, and hair may be fair, especially on children.

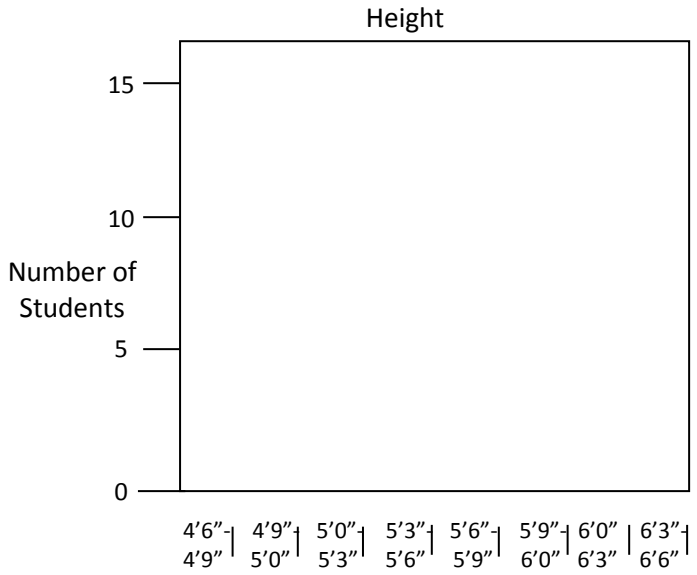
Name: _____ **Date:** _____ **Period:** _____

A. Answer the following questions about your traits by circling or writing in the correct answer. Do not fill in the last column at this time.

Traits				G ⟷ E 1 2 3 4 5
Do you have free earlobes?	Yes	No		
When you clasp your hands, which thumb is on top?	Left	Right		
Do you have mid-digital finger hair?	Yes	No		
Do you have any allergies?	Yes	No		
Can you roll your tongue?	Yes	No		
Do you have any body piercings?	Yes	No		
What is your height in feet and inches?				
What is your hair color?				
What is your hair length?				
How do you rate your athletic ability?	High	Moderate	Low	
How do you rate your artistic ability (e.g. musical, drawing, painting)?	High	Moderate	Low	

B. Add your data to each of the two class histograms of mid-digital finger hair and height by placing a sticky note at the correct position. Stack sticky notes at the same position in a neat column. After everyone has posted his or her data, draw the class results on the figure below.





C. Work with a partner to fill in the right-hand column of Part A. You can also list additional traits that are not on the survey.

Questions

1. What do you notice about the distribution of your class traits for mid-digital finger hair and height? What does this tell you about the kinds of traits these are?

2. Name two multifactorial traits, and explain how both genetic and environmental factors contribute to each trait.

Multifactorial Trait 1:	
Genetic Factor	Environmental Factor
Multifactorial Trait 2:	
Genetic Factor	Environmental Factor

3. Which category do you think most human traits fall into, genetic, environmental, or multifactorial?

4. What category does type 2 diabetes fall into? Justify your answer.

5. What are the implications of your answer to the previous question on the study of diseases like type 2 diabetes?